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RESEARCH ARTICLE

Accumulation of heavy metals in Mangroves (*Avicennia marina*) from Syhat and Safwa region, Tarut Bay Saudi Arabia.

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Abstract

The presence of mangroves in the marine environment has a special interest due to their potentials accumulation of heavy metals. In this study, we investigated the accumulation of heavy metals (Zn, Cr, Ni, Fe, As, Hg, Cu, Pb, Cd) in mangrove plants in the regions of Syhat and Safwa in Tarut Bay in Eastern Saudi Arabia. Analyses of water samples, soil and mangrove shows that concentrations of heavy metals were higher in mangrove plants compared to water and soil. We observed accumulating of high concentrations in mangrove for Zn, Cr, Ni, Fe, As (Zn (11.091 ppm), Cr (3.051 ppm)). The mangroves absorb and accumulate greater quantities of heavy metals and therefore play an important role in cleaning of the coastal environment of these toxic heavy metals.

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Introduction

The wealth of the Eastern Province in oil has helped this region to own a larger industrial area in the Kingdom of Saudi Arabia; about 86% of the industrial area of the country. This industrial progress has increased the pollution of this region. The main sources of this pollution are the petroleum industries, mining, municipal waste and wastewater (Al-Khateeb & Leilan, 2005). The Gulf War in 1991 brought severe environmental damage to the Gulf region. The world's largest oil spill was estimated at nearly as much as 8 million barrels (Metz, 1993). In addition, the activity of petroleum industries, discharge of industrial waste and oil spills from ships (Literathy et al., 2002) are the sources of contamination of the marine environment by oil and chemicals.

Among the most dangerous environmental contaminants, heavy metals. To fix this problem, several phytoremediation technologies was established; for cleaning soils (Baker et al., 1994; Salt et al., 1998; Terry & Banuelos, 2000), mine wastes and sewage (Ait et al, 2004; Von & Max, 1984; Xingmao Havelka, 2009), streams (Dushenkov et al, 1995) by the use of about 400 plant species capable of accumulation of toxic heavy metals. This method of phytoremediation (Salt et al., 1998) can absorb and remove contaminants from polluted soil and water is an efficient and friendly mechanism for the environment. Among these plants, we find the mangrove (*Avicennia marina*) (MacFarlane & Burchett, 2002; MacFarlane et al., 2003; Suresh & Ravishankar, 2004; MacFarlane et al., 2007; Isaiah et al., 2011). Others have suggested using some other plants in phytoremediation such as: sunflower, *Phragmites*, *Spartina*, cordgrass, *Salix*, *Typha*, *Tamarix*, *Arabis gemmifera*, *Thlaspi caerulescens* and tobacco (Kubota & Takenaka, 2003; Zhao et al., 2003; Adler, 2007; Manousaki et al, 2007;. Al-Taisan, 2009).

Mangrove in Tarut Bay has an important role in cleaning the marine environment in this region. Thus, this study focuses on the accumulation of heavy metals in the mangrove and in water and soil at two sites (Syhat and Safwa) in the region of Tarut Bay.

Material and Methods:-

Samples taken in this study were collected from two sites in Tarut Bay, Eastern Province-Saudi Arabia, during the period from December 2014 to January 2015. Tarut Bay is located along the coastline of the Arabian Gulf. The bay surrounds one of the largest islands in the Arabian Gulf—Tarut—which has an area of approximately 70 square kilometers (27 square miles). The island hosts both suburban development and fishing industries. It is linked to the mainland city of Qatif to the west by two causeways that cross a narrow channel of the bay. Tarut Bay extends from the King Abdulaziz seaport of Dammam and end at Ras Tanura, covering an area of 410 k² as shown in Figure 1.

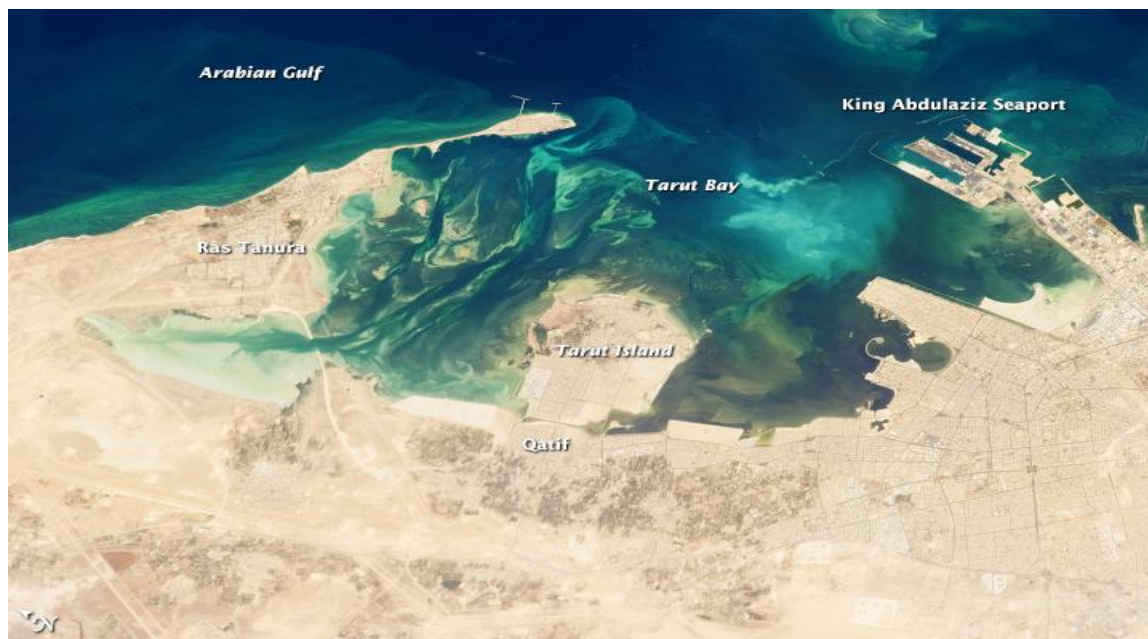


Figure 1:- Tarut Bay (picture from earth observatory, <http://earthobservatory.nasa.gov/IOD/view.php?id=81255>)

The GPS points of the study sites is shown in Table 1, the points were determined with a mobile GPS.

Table 1:- GPS points of the study sites

Sites	GPS
Site 1: Syhat	N 26°28.167' E050°04.138'
Site 2: Safwa	N 26°40.042' E049°59.527'

Samples taken from two sites (syhat and safwa in Tarut bay); water, soil and plants have been used to determine the concentrations of nine heavy metals: Arsenic, Nickel, Zinc, Iron, Lead, Cadmium, Copper, chromium and mercury. Three water samples were taken from each of two sites in 250 ml polyethylene container, and acidified by addition of 2 ml of HNO₃ in 1 liter of water, to prevent the absorption of heavy metals on the vessel walls. The samples were then transported to the laboratory at (4 ° C) and heavy metals were analyzed on the same day, using the Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES ; Varian 720-ES) (Clesceri et al., 1998).

Three samples of soil were taken from the surface of soil (0-10 cm) of each site. Then digests with 8 ml HNO₃ (65%) in a microwave mineralization (microwave Milestone Ethos one) (ISO 16729:2013 Soil quality - Digestion of soluble elements in nitric acid). The heavy metals were determined by the Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES ; Varian 720-ES) and they were quantified in ppm.

Three Mangrove samples were taken at random in both locations and dried in electrical oven. Mangrove plant were separated and analyzed as total plant, leaves and stems. Then digests with 8 ml HNO₃ (65%) in a microwave mineralization (microwave Milestone Ethos one). The heavy metals were determined by the Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES ; Varian 720-ES) and they were quantified in ppm.

Mercury analysis in all samples; water, soil, plant has been realized using the Direct Mercury Analyser (DMA-80, Milestone).

The data obtained was analyzed using the software SPSS version 22 (IBM SPSS Statistics 22).

Results:-

Water samples analyzed for heavy metal accumulation showed that As, Hg, and Zn were present in all samples ranged from 0.006-0.012 ppm, 0.0015-0.002 ppm and 0.002-0.004 ppm respectively. and 0.001ppm as a maximum for nickel in all samples. for others element; Cd, Pb, Fe, Cu, Cr concentrations are less than 0.001 ppm in all samples as shown in Table 2.

Table 2:- Variations in heavy metal contents (ppm) in water at the two Sites in the study area

Sites	As	Hg	Cd	Fe	Ni	Cr	Cu	Pb	Zn
Syhat	0.012 ±0.0023	0.002 ±0.0001	<0.001 ±0.0000	<0.001 ±0.0000	0.001 ±0.0005	<0.001 ±0.0000	<0.001 ±0.0000	<0.001 ±0.0000	0.002 ±0.0001
Safwa	0.006 ±0.0011	0.0015 ±0.0003	<0.001 ±0.0000	<0.001 ±0.0000	<0.001 ±0.0000	<0.001 ±0.0000	<0.001 ±0.0000	<0.001 ±0.0000	0.004 ±0.0009

In soil samples, Cu and Pb were present in negligible quantities in all soil samples, Cd concentration is less than 0.001 ppm in all samples (<0.001ppm), others element were present in higher contents as shown in Table 3. The overall contents from highest to lowest in all sites were as follows: Cr→Zn→Ni→Fe→As→Hg→Cu→Pb→Cd. We recorded that the mean concentrations of heavy metals in Syhat site more than Safwa site.

Table 3:- Variations in heavy metal contents (ppm) in soil at the two Sites in the study area

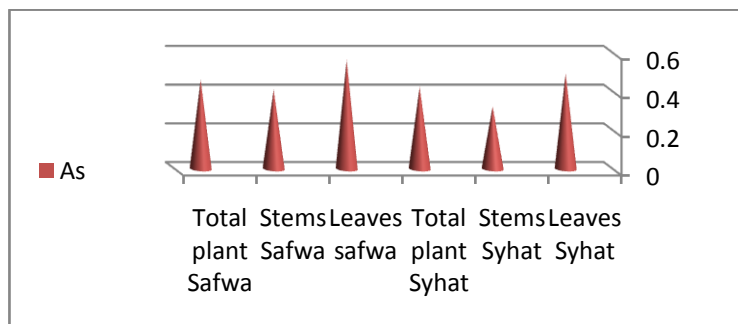
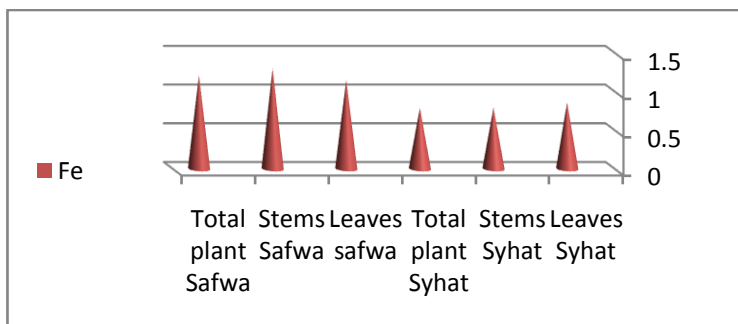
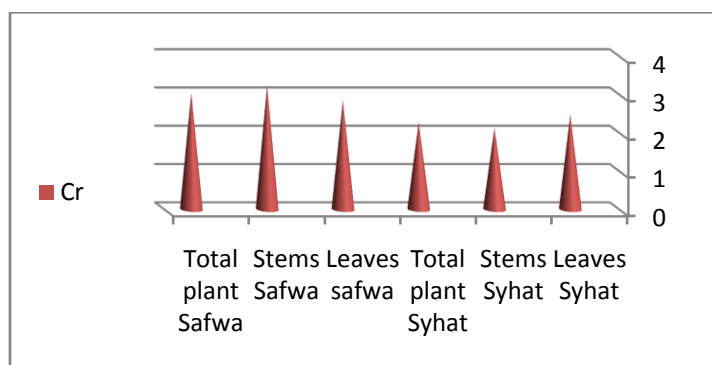
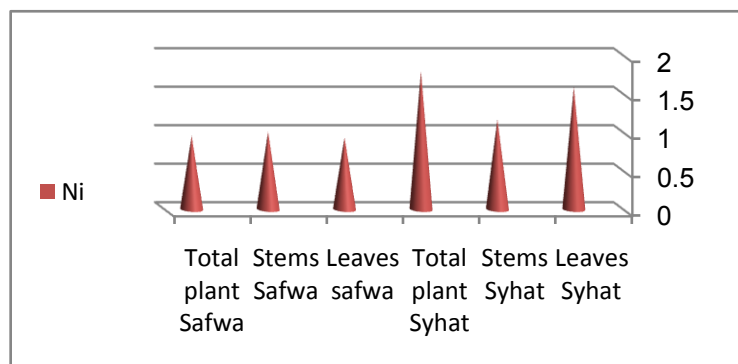
Sites	As	Hg	Cd	Fe	Ni	Cr	Cu	Pb	Zn
Syhat	1.825 ±0.056	0.057 ±0.007	<0.001 ±0.0000	3.789 ±0.205	6.348 ±0.295	16.697 ±0.548	0.044 ±0.0021	0.001 ±0.0001	10.971 ±0.620
Safwa	1.710 ±0.049	0.035 ±0.0003	<0.001 ±0.0000	2.705 ±0.185	5.292 ±0.274	12.491 ±0.487	0.032 ±0.0019	<0.001 ±0.0000	10.334 ±0.597

The analysis of mangrove samples for heavy metals accumulation showed that Zn and Cr elements were present at higher concentrations. While Cd, Cu and Pb were the least elements accumulated in the mangroves. An overall concentration of various elements from most abundant to least in plant samples were as follows:

Zn→Cr→Ni→Fe→As→Hg→Cu→Pb→Cd. It was observed that Safwa was the most polluted site. (Table 4 and Figure 2).

Table 4:- Variations in heavy metal contents (ppm) in mangrove samples

Sites	sample	As	Hg	Cd	Fe	Ni	Cr	Cu	Pb	Zn
Syhat	Leaves	0.492 ±0.023	0.039 ±0.006	<0.001 ±0.0000	0.859 ±0.04	1.590 ±0.201	2.485 ±0.148	<0.001 ±0.0000	<0.001 ±0.0000	5.645 ±0.220
		0.323 ±0.019	0.022 ±0.001	<0.001 ±0.0000	0.788 ±0.054	1.169 ±0.121	2.129 ±0.187	<0.001 ±0.0000	<0.001 ±0.0000	6.899 ±0.297
	Stems Total plant	0.423 ±0.018	0.030 ±0.002	<0.001 ±0.0000	0.798 ±0.047	1.795 ±0.204	2.279 ±0.104	<0.001 ±0.0000	<0.001 ±0.0000	6.184 ±0.197
		0.461 ±0.019	0.110 ±0.02	<0.001 ±0.0000	1.212 ±0.163	0.954 ±0.074	3.051 ±0.109	<0.001 ±0.0000	<0.001 ±0.0000	11.091 ±0.097
Safwa	Leaves	0.562 ±0.036	0.190 ±0.02	<0.001 ±0.0000	1.147 ±0.19	0.935 ±0.195	2.857 ±0.140	<0.001 ±0.0000	<0.001 ±0.0000	9.358 ±0.120
		0.409 ±0.017	0.044 ±0.002	<0.001 ±0.0000	1.298 ±0.178	1.009 ±0.094	3.247 ±0.117	<0.001 ±0.0000	<0.001 ±0.0000	13.669 ±0.197
	Stems Total plant	0.461 ±0.019	0.110 ±0.02	<0.001 ±0.0000	1.212 ±0.163	0.954 ±0.074	3.051 ±0.109	<0.001 ±0.0000	<0.001 ±0.0000	11.091 ±0.097
		0.461 ±0.019	0.110 ±0.02	<0.001 ±0.0000	1.212 ±0.163	0.954 ±0.074	3.051 ±0.109	<0.001 ±0.0000	<0.001 ±0.0000	11.091 ±0.097



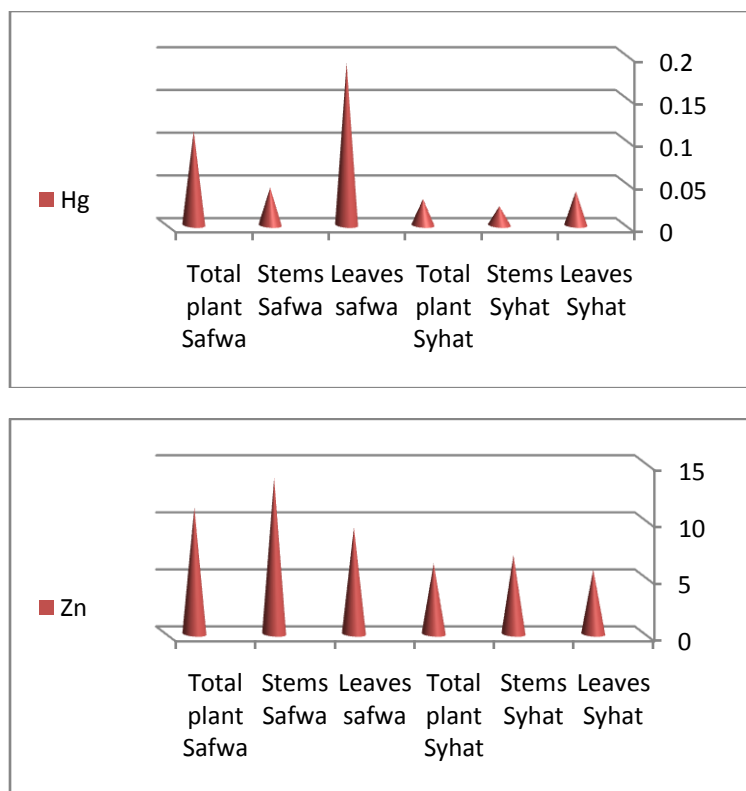


Figure 2:- Heavy metals in mangrove (ppm)

Discussion:-

The problem of contamination by heavy metals is a question of serious concern at the local, regional and global (Rai, 2008). Plants absorb heavy metals through their roots, or even through their stems and leaves, and accumulate in their tissues. (Ramos et al., 2006).

In this study, the results find for water samples showed the presence of arsenic, mercury and zinc with low concentrations, while the Cd, Cu, and Pb were uncommon in all samples. For soil samples we note the presence of As, Hg, Ni and Cr with high levels in the two sites.

In mangrove samples, Zn and Cr were abundant element. Cd was the element the least accumulated. Low Cd content may be due to its very low and slow acropetal translocation in plants (Wolterbeek & Van, 2002). It was observed that Safwa was the most polluted site due to the drainage water zone in Safwa. We observed that the average concentration of heavy metals in plant samples were significantly higher than the water and soil samples. It clearly demonstrated the mangrove ability as a vital heavy metal accumulation plant. So, it is very useful to have mangrove plants in costal regions for the absorption of contaminants and especially of heavy metals and cleaning of the marine environment.

Conclusion:-

The current study has shown that mangroves absorb large amounts of heavy metals from their environment, demonstrating the importance of these plants in the cleaning of the marine environment from pollutant. So it is recommended that the mangrove vegetation should be protected from various factors like human activities such as the construction of ports and fishing dams, invasion of sand dunes, camel grazing on mangrove leaves and sewage from industrial and residential areas.

References:-

1. Adler, A. (2007): Accumulation of elements in *Salix* and other species used in vegetation filters with focus on wood fuel quality. Uppsala: Dept. of Crop Production Ecology, Swedish University of Agricultural Sciences.
2. Ait, A. N., Bernal, M. P., & Ater, M. (2004): Tolerance and bioaccumulation of cadmium by *Phragmites australis* grown in the presence of elevated concentrations of cadmium, copper, and zinc. *Aquatic Botany*, 80(3): 163-176.
3. Al-Khateeb, S. A., & Leilan, A. A. (2005): Heavy Metals Accumulation in the Natural Vegetation of Eastern Province of Saudi Arabia. *Journal of Biological Sciences*, 5(6): 707-712.
4. Al-Taisan, W. A. (2009): Suitability of Using *Phragmites australis* and *Tamarix aphylla* as Vegetation Filters in Industrial Areas. *American Journal of Environmental Sciences*, 5(6): 740-747.
5. Baker, A. J. M., McGrath, S. P., Sidoli, C. M. D., & Reeves, R. D. (1994): The possibility of in situ heavy metal decontamination of polluted soils using crops of metal-accumulating plants. *Resources, Conservation and Recycling*, 11: 41-49.
6. Clesceri, L. S., Greenberg, A. E., & Eaton, A. D. (1998): Standard methods for the examination of water and wastewater (20th ed.). Washington: APHA American Public Health Association.
7. Dushenkov, V., Kumar, P. B. A. N., Motto, H., & Raskin, I. (1995): Rhizofiltration: The Use of Plants to Remove Heavy Metals from Aqueous Streams. *Environmental Science & Technology*, 29(5): 1239-1245.
8. Isaiah, N. K., Poliyaparambil, R. S., Rita, N. K., George, B., & Viyol, S. (2011): An Assessment of the Accumulation Potential of Pb, Zn and Cd by *Avicennia marina* (Forssk.) Vierh. in Vamleshwar Mangroves, Gujarat, India. University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, Romania.
9. Kubota, H., & Takenaka, C. (2003): Field Note: *Arabis gemmifera* is a Hyperaccumulator of Cd and Zn. *International Journal of Phytoremediation*, 5(3): 197-201.
10. Literathy, P., Khan, N. Y., & Linden, O. (2002): Oil and Petroleum industry. The Gulf ecosystem: Health and sustainability. Leiden: Backhuys, pp. 127-156.
11. MacFarlane, G. R., & Burchett, M. D. (2002): Toxicity, growth and accumulation relationships of copper, lead and zinc in the grey mangrove *Avicennia marina* (Forsk.) Vierh. *Marine Environmental Research*, 54(1): 65-84.
12. MacFarlane, G. R., Pulkownik, A., & Burchett, M. D. (2003): Accumulation and distribution of heavy metals in the grey mangrove, *Avicennia marina* (Forsk.) Vierh.: biological indication potential. *Environmental Pollution*, 123(1): 139-151.
13. MacFarlane, G. R., Koller, C. E., & Blomberg, S. P. (2007): Accumulation and partitioning of heavy metals in mangroves: A synthesis of field-based studies. *Chemosphere*, 69(9): 1454-1464.
14. Manousaki, E., Kadukova, J., & Kalogerakis, N. (2007): Excretion of metals by the leaves of plants: A new approach to the phytoremediation of sites contaminated with heavy metals. *Proceeding of the 10th International Conference on Environmental Science and Technology*, 916-923.
15. Metz, H. C. (1993): Saudi Arabia: A Country Study. Washington: GPO for the Library of Congress.
16. Rai, P. K. (2008): Phytoremediation of Hg and Cd from industrial effluents using an aquatic free floating macrophyte *Azolla pinnata*. *International Journal of Phytoremediation*, 10(5): 430-431.
17. Ramos, S. C. A., da, S. A. P., & de, O. S. R. (2006): Concentration, stock and transport rate of heavy metals in a tropical red mangrove, Natal, Brazil. *Marine Chemistry*, 99: 2-11.
18. Salt, D. E., Smith, R. D., & Raskin, I. (1998): Pytoremediation. *Annual Review of Plant Physiology and Plant Molecular Biology*, 49(1): 643-668.
19. Suresh, B., & Ravishankar, G. A. (2004): Phytoremediation - a novel and promising approach for environmental clean-up. *Critical Reviews in Biotechnology*, 24(2-3): 97-124.
20. Terry, N., & Banuelos, G. (2000): *Phytoremediation of Trace Elements*. Lewis Publishers, Boca Raton, pp. 389.
21. Von, O. I., & Max, F. C. (1984): Wastewater treatment with aquatic plants: Ecotypic differentiation of *Typha domingensis* seedlings. *Environmental Pollution. Series A. Ecological and Biological*, 35(3): 259-269.
22. Wolterbeek, H. T., & Van, M. A. J. (2002): Transport rate of arsenic, cadmium, copper and zinc in *Potamogeton pectinatus* L.: radiotracer experiments with ⁷⁶As, ¹⁰⁹,¹¹⁵Cd, ⁶⁴Cu and ⁶⁵,⁶⁹mZn. *The Science of the Total Environment*, 287: 1-2.
23. Xingmao, M., & Havelka, M. M. (2009): Phytotoxicity of chlorinated benzenes to *Typha angustifolia* and *Phragmites communis*. *Environmental Toxicology*, 24(1): 43-48.
24. Zhao, F. J., Lombi, E., & McGrath, S. P. (2003). Assessing the potential for zinc and cadmium phytoremediation with the hyperaccumulator *Thlaspi caerulescens*. *Plant and Soil*, 249(1): 37-43.